The visual observations corroborate the photographs in showing that at this eclipse the shadow was especially black, so that no details of the eclipsed surface could either be seen or photographed. This result differs greatly from that recorded for the eclipses of December, 1898, and December, 1899, when the eclipsed surface was plainly visible and of a marked ruddy colour.

THE OCCURRENCE OF SPARK LINES IN ARC SPECTRA.—In a paper which recently appeared in the *Sitzungsberichte der K. Akademie zu Berlin* (January 22), Messrs. J. Hartmann and G. Eberhard give the results of a number of experiments they have made in order to determine under what conditions various lines, usually associated with spark spectra, may appear in the spectrum of the arc.

In the cases of magnesium and silicon—which are so important when considering stellar spectra—the authors found that when the arc was produced under water, using metallic poles, the magnesium line at λ 4481 and the silicon lines at λλ 4128 and 4131 were produced, although all three are usually called "spark" lines. In the case of zinc, the "spark" lines at λλ 4912 and 4925 were obtained under similar conditions.

The authors have also photographed the spectra of these metals when the arc was enclosed in an atmosphere of hydrogen, and again, under these conditions, the "spark" lines appeared. From this similarity of the results Messrs. Hartmann and Eberhard arrive at the conclusion that, when the arc is struck under water, it immediately becomes surrounded by an atmosphere of hydrogen, produced by the decomposition of the water, and so the same results under the two different primary conditions are obtained (*Astronomische Nachrichten*, No. 3858).

FOUR STARS WITH VARIABLE RADIAL VELOCITIES.—In *Bulletin* No. 31 of the Lick Observatory, Mr. H. M. Reese announces the discovery of four more stars having variable velocities in the line of sight; they are as follows:—

υ Andromedae.—Plates secured on October 8 and November 5, 1902, and January 14, 1903, show velocities of −17 km., −76 km., and +49 km. respectively. The spectrum shows few lines, and the hydrogen lines are broad, but the helium lines are fine and easily measurable.

π^4 *Orionis.*—The plates obtained on October 6, 1902, January 4 and January 12, 1903, indicate velocities of +43 km., ±0 km., and +6 km. respectively, the spectrum being similar to υ Andromedæ.

σ Geminorum.—Velocities of +74 km., +12 km., +9 km. and +69 km. are indicated by negatives obtained on March 16, 1902, January 12, 13, and February 15, 1903, respectively. The lines, though numerous, are rather hazy, but they give trustworthy results.

ι Argus.—The variable velocity of this star was discovered by Prof. Campbell from the comparison of a plate obtained on February 21, 1898, with previous measures. A series of seven photographs obtained between February 23, 1897, and February 18, 1902, shows a range of velocity from +41·9 km. to +50·3 km.

The photographs mentioned above have been obtained with the Mills spectrograph, and measured by Messrs. Reese and Curtis. Mr. Reese also announces that the star ϕ^2 Orionis is an especially interesting object on account of its great radial velocity, plates obtained on October 28, November 24, and December 30, 1902, indicating velocities of +94 km., +102 km., and +96 km. respectively. The range of 8 km. may not be taken as indicating a variable velocity for this star, for although the photographs show fairly good lines, the second one—in which the variation appears—was very much under-exposed.

THE HARVARD MERIDIAN PHOTOMETER OBSERVATIONS.—Part ii. vol. xliv. of the Harvard College Observatory *Annals* is devoted to a description of the reduction of the observations made with the meridian photometer during the years 1892–98. The editor, Prof. E. C. Pickering, gives a detailed description of the meridian photometer and the methods pursued in making the observations. This description is followed by tables giving the results of the observations of Harvard photometer and A.G. catalogue stars made during the period named above, each table being followed by voluminous notes as to the peculiarities of the observed objects and the observing conditions.

ENGINEERING EDUCATION ABROAD.

THE conditions governing the competition among the great manufacturing countries for the markets of the world have, during the last thirty years, undergone profound modification. At the beginning of the latter half of last century British manufacturers held an unique position which secured for them what was practically the monopoly in some departments of the world's trade. The reasons for this fortunate position are too well known to require elaborate recapitulation. It is enough to remember that while other countries were on one hand engaged in war and on the other in maturing a stable and enduring constitution, Britain was establishing flourishing manufacturing centres, which, with the assistance of her possession of coal and iron, supplemented as it was by the natural endowments of her citizens so far as perseverance and inventiveness were concerned, resulted in her becoming the world's workshop. In no direction was this supremacy more pronounced than in the several branches of the engineering trades. But since then great changes have taken place. By carefully laid plans and persistent effort, other countries have succeeded in overcoming their disadvantages, and as a result of the provisions they have made for the education of their young men in scientific technology, the British manufacturer has now to reckon with formidable German and American competitors.

The changed conditions have been made the subject of study by several authorities in this country, one of the most recent being Prof. W. E. Dalby, who has studied the question of the education provided for engineers in America, Germany and Switzerland. The opportunity which his commission from Mr. Yarrow to report on the training of engineers in other countries has given Prof. Dalby make the recent papers read by him before the Institution of Naval Engineers and the Institution of Mechanical Engineers of exceptional value, and it is much to be hoped that the following facts from his papers, and the lessons to be drawn from them, may have a good effect in convincing our manufacturers and educational authorities that the higher education of those engaged in industrial pursuits has a direct and immediate effect on success in the struggle for commercial supremacy.

The paper read before the Institution of Naval Architects was concerned only with the education of engineers in the United States; that before the Institution of Mechanical Engineers included a study of the question in Germany and Switzerland also. It will be most convenient to take these countries in order. Beginning with the United States, the nature of the technical education in the best colleges may first be considered, and then the relation between the employers and the technically trained men graduating from these colleges.

America.—A good idea of the aims of the technical colleges of America may be gathered from the words of one of the chief founders of the Massachusetts Institute of Technology of Boston, who laid it down that the most truly practical education, even in an industrial point of view, is one founded in the thorough knowledge of scientific principles, which unites with habits of close observation and exact reasoning a large general cultivation. The highest grade of scientific culture is not too high a preparation for the labours of the mechanic and manufacturer, and there are in the history of social progress ample proofs that the abstract studies and researches of the philosopher are often the most beneficent sources of practical discovery and improvement.

Inspired by such enlightened views of technical education, it is not surprising that there has been a steady increase in the number of engineering students in the chief American colleges. The first table on p. 18 gives an idea of the growth of their engineering departments.

At Cornell University students of mechanical engineering and the allied branches do their work at Sibley College; there is a separate building for civil engineering and architecture. Sibley College is divided into eight departments, viz. mechanical engineering, mechanical laboratory instruction, electrical engineering, mechanic arts (workshops), industrial drawing and art, machine design, graduate schools of marine engineering, and the graduate school of railway mechanical engineering.

Showing Numbers of Students in Engineering in Certain Colleges.

	YALE. Civil, Mechnical, Electrical, Mining and Sanitary Eng. Students in the Sheffield Scientific School.	CORNELL. Civil, Mechanical and Electrical Students.	MASS. INST. Civil, Mechanical, Electrical and Mining Students.
1895–96	209	617	357
1896–97	174	623	352
1897–98	153	645	356
1898–99	166	686	347
1899–00	162	774	356
1900–01	163	844	372

The staff consists of thirty-six teachers and instructors, and this number includes six professors and four assistant professors, and eight non-resident lecturers. The staff is inadequate at the present to deal with the numbers of students in the college.

A great feature of this institution is its workshops. Here instruction is given in pattern-making, moulding, forging, fitting and turning, and the work done in them is real. All students in the college pass through the same course during the first three years. They may specialise in the fourth year in steam, marine, railway or electrical engineering with specialists in those subjects.

Admission to the course in the American college is by examination. To enter Cornell a student must be sixteen years of age, and to enter the Massachusetts Institute seventeen. The standard of examination is such that a youth from a good high school can pass. There is no freedom left to the student regarding his course of studies when once he has chosen his department. Examinations are frequent, and promotion from one year to another depends upon the result of them. The courses are really a carefully-thought-out and elaborately organised species of educational drill. As a general rule a man must go through with it or fall out.

At the Massachusetts Institute the courses are so arranged that a student can do his work in forty-eight hours per week. Half of this time is given to lectures, &c., at the college, the other half is assumed to be spent in private study. The same method appears to be in operation at Cornell, Harvard and Yale. An analysis of the courses shows what is understood by a technical education in the States; it is really four years of continuous hard work at a college equipped with engineering laboratories and workshops, and with all the educational apparatus for giving a scientific education.

It is interesting to note the attitude of employers in the United States to the men who study in the way just described in these American colleges. A point in which American practice is remarkably different from ours is that age is no limit to a man who wants to get practical work in the shops, providing he is a college graduate. Employers might not take on an apprentice after twenty-one years of age if he were not a graduate. College graduates in America never find that, whilst learning the scientific principles of their profession, they have grown too old to enter the workshops to learn the practical part. The general opinion seems to be that the educated man picks up his practice much quicker and more intelligently than the younger man with only an ordinary education. Generally speaking, the attitude of the American employer towards these graduates is one of distinct encouragement, and of advantage to both. The employer gets the advantage of a trained intellect, the employee gets the advantage of his employer's shops and business experience. The American employer keeps an "open door" for the technically trained man, whilst with us in England the door is too often closed by rules regarding age and the like, and the would-be apprentice not having sufficient means to pay a premium in addition to the amount he has already paid for his education. In cases where college graduates are taken on in England, they are, as a rule, expected to go through the same course in the shops as a boy entering straight from school. The Americans are more yielding in this respect, and do not insist upon the drudgery of the first few years.

Germany.—The Berlin Technical High School at Charlottenburg is a State institution, and its object is to give a specialised training in industrial subjects founded on a preliminary scientific education. The course, lasting four years, begins with scientific subjects, and gradually becomes more technical until in the fourth year all the subjects are specialised. German subjects are admitted to the school on the production of a "maturity certificate" from a German gymnasium or a Prussian real-gymnasium. The education given at the two kinds of schools corresponds very roughly with that given in the classical and modern courses of our public schools. The maturity certificate is obtained at the end of a nine years' course. Those admitted by means of this certificate are styled *Students*.

Persons who cannot obtain or have not obtained this certificate can be admitted on school certificates of a lower value, but for the departments of architecture, civil and mechanical engineering and naval architecture must in addition show that they have worked for at least one year in some works. Those entering in this way are styled *Hospitanten*. The school has recently been given the status of a university.

As an instructive indication of the importance attached to higher technical education in Germany, the tables which have been drawn up by Prof. Dalby showing the numbers of students and teachers at the Charlottenburg institution may be given:—

Students of Various Grades in Attendance for the Winter Half-Year, 1902–3.

	Students.	Hospitanten.	Total.
1. Architecture	477	262	739
2. Civil Engineering	647	42	689
3. Mechanical Engineering:			
Specialising in Mechanical Engineering	1319	180	1499
Specialising in Electrical Engineering	270	51	321
4. Naval Architecture:			
Specialising in Naval Architecture	241	18	259
Specialising in Marine Engineering	106	17	123
5. Chemistry and Metallurgy:			
Specialising in Chemistry	161	20	181
,, ,, Metallurgy	169	11	180
6. General Science	6	—	6
Persons admitted under special regulations from affiliated Institutions	—	—	80
Officers and Engineers from the Navy	—	—	301
Total	3396	601	4378

Teaching Staff.

	Architecture.	Civil Engineering.	Mechanical Engineering.	Naval Architecture.	Chemistry.	Science.
Professors	18	14	20	6	13	18
Priv. Docenten	17	8	8	1	17	15
Construction Engineers	—	—	7	2	—	—
Lecturers.	—	—	—	—	—	2
Assistants	1	1	13	3	15	4
Honorary Assistants.	53	33	67	9	10	27
Total	89	56	115	21	55	66

Expressed briefly, there are 4378 students of all kinds and 402 members of the teaching staff.

A distinguishing characteristic of the Berlin Technical High School is the right maintained by the students to choose their own courses of study. This freedom is common to German universities, and it follows that the educational authorities can only suggest courses of study, leaving the students free to follow their suggestions completely, or partially, or not at all. Nevertheless, very complete and elaborate courses have been arranged, and as a rule are followed by the students.

There is no attempt to teach workshop practice. Laboratory teaching is confined to the engine laboratory and the electrical laboratory, with a little practice in testing materials at the neighbouring Government testing establishment (Königliche mechanische-technische Versuchanstalt).

The most striking feature of the course is the relatively large amount of time devoted to machine construction, including machine drawing, graphic statics, descriptive geometry, and the lectures connected with the various forms of machines, in which exercises in the drawing office are given. Prof. Riedler, who is at the head of this department, carries on a large engineering practice in the building, employing between twenty and thirty draughtsmen. The majority of these men take part in teaching the subject, so that mechanical drawing and machine design are taught by practical draughtsmen engaged for the greater part of their time in actual designing. No better method than this could be devised, because to all intents and purposes the students are working under actual drawing-office conditions.

A student passing through this course has a large amount of drawing-office practice of an advanced character, but very little practical work. Whether this kind of training is the best is a matter of opinion, but Prof. Dalby thinks a course which makes less claim on the students' time for college work and allows more for practical work would, on the average, in the long run produce better engineers.

Switzerland.—The Polytechnic at Zurich is a State institution designed to give a specialised training in industrial subjects. The course lasts four years. Students are admitted by examination at eighteen years of age. A "maturity certificate" from a Swiss school is taken in lieu of an examination, or a student may be excused part of the entrance examination by presenting certain school certificates. During 1901–2, there were 181 Swiss students of civil engineering, 230 studying mechanical engineering, and 49 taking up architecture, and in addition 249 foreigners in the same departments.

The lectures and exercises as announced in the programme of the several departments are obligatory on the student. In each department, however, the students are allowed a choice in the third year. Once having chosen, they are obliged to follow the plan selected. As at Berlin, no attempt is made to teach workshop practice, but the bulk of the time is given to drawing-office work.

General Remarks.—In all the courses described, a common scientific basis in the first two years develops into widely divergent and specialised branches in the remainder of the course. It should be understood that both in the States and on the Continent many of the specialised lectures are given by men in the full practice of their profession, and who are not regular members of the teaching staff. The best courses in this country are arranged on practically the same basis, but the longest being three years, there is no time to develop the instruction into the specialised branches of engineering.

There is an essential difference in the method of training in America and Germany. In America the course of instruction is very exactly laid down, and the student is compelled to follow it step by step. Slight variations are permitted in the form of options, to use their term, in the later periods of the course. The student gets his degree from the gradually accumulating results of terminal and sessional examinations, ending finally with a thesis.

In Germany the students of their great technical high schools enjoy the freedom peculiar to the university system of that country. No student is compelled to take any special course. For his convenience definite courses are arranged and laid down in the school calendar, but the sequence of lectures therein stated is not binding. The courses are only recommendations, and students may follow them or not as they please. At Zurich the course is partly prescribed, partly selected.

The following table gives a good idea of the nature of the engineering courses in the three countries, the subjects studied, and the relative importance attached to each.

The Percentage Number of Hours' Instruction given in Various Mechanical Engineering Courses.

	Massachusetts Institute.	Cornell.	Berlin Technical High School.	Zurich Polytechnic.
Mathematics	8	5	14·5	19·2
Physics	5	8	6·8	6·0
Chemistry	7	7	1·7	3·0
Applied Mechanics	7	10[1]	22·5	19·5
Mechanism	4	—	8·0	—
Steam-Engine, including Thermodynamics	6	6	4·1	8·0
Mechanical Drawing[2]	26	20	31·0	39·3
Electrical Engineering	2	2	3·4	5·0
Commercial Subjects	2	—	8·0	—
Workshops	14	30	Nil	Nil
French	6	—	,,	,,
German	3	3	,,	,,
English	5	—	,,	,,
Engineering Laboratories	5	9	[3]	[3]
	100	100	100·0	100·0
Approximate Hours	3000	3000	4000	4000
Distributed over	Four Years.	Four Years.	Three Years.	Three Years.

The fourth year of the continental courses is not included, because it is so cut up with examination work. It must not be forgotten, however, that an American student actually receives 3000 hours' instruction; a German or Swiss student is only recommended to attend courses aggregating 4000 hours. Actually he may work just as many hours as he chooses. In brief, the American courses are more practical in character, they include more laboratory training than is recommended in the German course, and devote a large proportion of the course to the teaching of handicraft skill. In Charlottenburg and Zurich no attempt is made to teach handicraft skill, and the bulk of the training is given in the drawing-office, though in addition a considerable amount of time may be given to engine testing.

One thing is certain, the American, German, and Swiss student starts his course with a far better education on which to build than is the case with us. Much time is wasted at colleges here on teaching things which should have been taught at school. Prof. Dalby believes that the great defect of the British system of training engineers is the want of coordination between the colleges and the employers. If the employers will concern themselves with the question, he feels sure their attitude will speedily change.

The general opinion seemed to be that a course arranged so that the winter months are spent at college and the summer months in the works is a desirable one, and one from which good results may be expected. Such an arrangement obviously cannot be worked without the cooperation of the employers. This alternating system must not be regarded as experimental. Our Admiralty have had something very similar in operation for forty years, and the system has produced a famous roll of chief constructors The Scottish universities lend themselves to the system, and Glasgow students in engineering consistently study in the winter and work in the summer.

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[1] Includes Mechanism.

[2] Includes Freehand, Machine Drawing and the lectures connected with Machine Design.

[3] Laboratory courses are taken in addition, but it is difficult to estimate how much is recommended.